

Heat injuries in Canadian mass participation runs

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In two Canadian runs with a total of approximately 2900 participants 26 people collapsed with heat injury and were taken to hospital. All were relatively young (13 to 38 years old). A retrospective survey showed that all were novices to 10-km races and that many had collapsed even though they had consumed fluids before and during the run. A review of etiologic factors suggested that the extremes in the Canadian climate, which preclude heat acclimatization in the spring and early summer, may be an important influence on the incidence of heat injury.

Dans deux courses tenues au Canada et impliquant un total d'environ 2900 participants 26 personnes accablées par la chaleur furent transportés à l'hôpital. Tous étaient relativement jeunes (13 à 38 ans). Une enquête rétrospective révéla que tous étaient novices aux courses de 10 km et que plusieurs s'étaient effondrés en dépit du fait qu'ils avaient consommé des liquides avant et durant la course. Une revue des facteurs étiologiques a indiqué que les extrêmes du climat canadien, qui empêchent l'acclimatation à la chaleur au printemps et au début de l'été, peuvent avoir une importante influence sur la fréquence des atteintes dues à la chaleur.

Heat stroke during work in a hot environment has frequently been reported.¹ Until recently most heat injuries were associated with very high temperature, humidity and level of solar radiation. However, with mass participation jogging events heat injuries are occurring in less extreme conditions. Many running events have been plagued with heat injuries requiring hospitalization.²⁻⁴ We studied two races conducted in Ontario during the summer of 1978 to determine the frequency of hospitalization for heat injury and the possible causes of this problem.

The races

The first race was a 10.3-km event conducted June

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11, 1978 in Waterloo, Ont. It started at 1 pm, when the temperature at the local weather station was 24.3°C, the humidity 49%, the wind velocity 16 knots and the cloud cover minimal, allowing much radiant heat. Little shade was available on the race route, so that the resulting temperature on the asphalt and gravel running surfaces was probably higher. This was the hottest day of the summer so far; most of the days in June prior to the race day had had a maximum temperature in the range of 17 to 21°C. The race organizers had established one water station, at the half-way point. Approximately 1250 people (18% female) participated in the run. Their ages ranged from pre-teen to over 50 years, but most were 20 to 35 years. Approximately 75% to 80% of the finishers completed the event in less than 60 minutes. Fifteen people were admitted to hospital, all because of collapse due to heat injury. They were transported from the point of collapse on a city street or the first-aid station at the finish line to one of two city hospitals. Three patients were female and 12 were male; they represented 1.3% and 1.2% respectively of all the female and male competitors.

The second race was conducted Aug. 13, 1978 in Toronto. It was open to females only and covered 10 km. The race started at 10 am, when the temperature was 31.8°C, the humidity 61%, the wind velocity 9 knots and the cloud cover minimal. As in the Waterloo run little protection from the solar radiation was available. The organizers had four water stations at intervals along the route, with cups of water and hoses available. A total of 1658 people, ranging in age from 10 to over 60 years, started the race. Eleven (0.7%) were admitted to hospital because of heat injury. They were transported first to a central first-aid station and then to Scarborough Centenary Hospital.

Survey of patients

Methods

By means of a survey we attempted to determine if various factors were common to those collapsing because of heat injury. The medical records departments of the pertinent hospitals checked for all admis-

sions due to participation in the races and contacted the patients to obtain permission for us to review their records and to send them a survey form. Of the 15 patients admitted to hospital after the first race 14 agreed to participate in the survey and 12 returned their forms. Of the 11 admitted to hospital after the second race all agreed to participate and 8 returned their forms. Information was obtained on age, height, weight, prior training, fluid consumption before and during the race, reaction to impending collapse and perceived running effort.

Results

A summary of the patients' responses is presented in Tables I and II. The patients were relatively young (age range 13 to 38 years). All were novices to 10-km races, although a small number had raced shorter distances. In prior training they had avoided the heat of the day; all had completed a 10-km run in training. Fluids had been consumed prior to the race by all but one of the patients. The estimated fluid consumption was higher during the Toronto run than during the Waterloo run, probably because there were more water stations at the former. Two Toronto patients (nos. 3 and 4 in Table II) had avoided fluid consumption because they feared stomach distress.

The reactions of the patients to impending collapse were notable. The typical symptoms of heat distress, such as excessive sweating, pain in the temples, dizziness, nausea and, in a few, anhidrosis and cold skin, were experienced; however, all the patients believed that they could continue. As a result of continued running the consciousness of the nine men gradually became impaired. The female respondents either made no mention of impaired consciousness or reported a loss of concentration.

The patients rated their running effort on a scale of 1 to 10, with a typical training effort equal to 5. Their average rating, 7 to 8, indicates that these novice 10-km runners were unable to judge as maximal the effort that resulted in their collapse. The highest ratings were given by those who attempted to race for top finishing positions. Most of the patients collapsed after completing the 10 km, but some collapsed as early as 6 km.

Treatment of all the patients was begun immediately. The skin was cooled and the patients were transported to hospital.

In no case was the rectal temperature measured at the race site. The rectal temperatures recorded in hospital after the initial treatment were within the normal range. Four of the patients from the Waterloo run were unresponsive to verbal stimuli when admitted

Table I—Responses to survey questions of persons in the 10.3-km Waterloo run who collapsed because of heat injury and were admitted to hospital

| Patient no. | Sex | Age (yr) | Height (cm) | Weight (kg) | Fluids consumed (ml) | | Running effort* | Point of collapse | Hospital stay |
|-------------|-----|----------|-------------|-------------|----------------------|------------|-----------------|-------------------|---------------|
| | | | | | Morning before run | During run | | | |
| 1 | F | 14 | 162 | 46.7 | 300 | 100 | 7 | Unknown | < 4-5 h |
| 2 | F | 17 | 173 | 49.9 | 0 | 200 | 8 | Finish | < 4-5 h |
| 3 | F | 18 | 162 | 53.0 | 600 | 0 | 7 | Finish | Overnight |
| 4 | M | 17 | 173 | 61.2 | 250 | 250 | 6 | 6 km | < 4-5 h |
| 5 | M | 18 | 183 | 62.5 | 900 | 0 | 9 | Finish | 4 d |
| 6 | M | 19 | 178 | 65.8 | 750 | 200 | 7 | 8 km | < 4-5 h |
| 7 | M | 21 | 187 | 68.0 | 1200 | 200 | 8 | Finish | Overnight |
| 8 | M | 23 | 173 | 68.0 | 500 | 150 | 8 | Finish | < 4-5 h |
| 9 | M | 29 | 180 | 81.6 | 500 | 50 | 7 | Unknown | Overnight |
| 10 | M | 34 | 180 | 72.6 | 500 | 0 | 7 | 7 km | Overnight |
| 11 | M | 35 | 183 | 73.4 | 600 | 50 | 8 | Finish | Overnight |
| 12 | M | 38 | 193 | 97.5 | 500 | 0 | 7 | 7 km | 4 d |

*Rated by the respondent on a scale of 1 to 10, with a typical training effort equal to 5.

Table II—Responses of similar victims in the 10-km Toronto run

| Patient no. | Sex | Age (yr) | Height (cm) | Weight (kg) | Fluids consumed (ml) | | Running effort* | Point of collapse | Hospital stay |
|-------------|-----|----------|-------------|-------------|----------------------|------------|-----------------|-------------------|---------------|
| | | | | | Morning before run | During run | | | |
| 1 | F | 13 | 173 | 72.6 | 500 | 250 | 8 | Finish | < 4-5 h |
| 2 | F | 14 | 150 | 50.8 | 400 | 100 | 7 | 7 km | < 4-5 h |
| 3 | F | 16 | 173 | 54.4 | 500 | 0 | 6 | Finish | < 4-5 h |
| 4 | F | 17 | 165 | 55.3 | 750 | 0 | 9 | 9.8 km | < 4-5 h |
| 5 | F | 18 | 157 | 49.9 | 400 | 400 | 9 | 6 km | < 4-5 h |
| 6 | F | 27 | 165 | 56.7 | 1000 | 50 | 7 | Finish | < 4-5 h |
| 7 | F | 28 | 166 | 57.6 | 200 | 300 | 10 | 9 km | < 4-5 h |
| 8 | F | 30 | 160 | 53.5 | 250 | 500 | 8 | Finish | < 4-5 h |

to hospital, which suggested heat stroke. The only remarkable findings at the time of admission were low blood pressure in patient 3 (95/20 mm Hg) and patient 6 (80/20 mm Hg) from the Waterloo run. Hemoconcentration was observed in all the patients from whom blood samples were drawn; however, the values were not outside the normal limits. Similarly, the serum electrolyte levels were within the normal range at the time of admission.

All the patients from the Toronto run were discharged within 4 to 5 hours. Of the 12 survey respondents from the Waterloo run 4 were discharged after a few hours, 6 remained in hospital overnight and 2 were kept in hospital for 4 days.

Discussion

One of the most notable occurrences of heat injury in a distance running event was in Vancouver in the 1954 Empire Games. The English marathon runner Jim Peters was disoriented on entering the stadium and collapsed before crossing the finish line. The occurrences in our report differ in many ways from that dramatic event. Today large numbers of Canadians are taking part in physical fitness programs and are entering mass participation events. Most of these people are not elite athletes. It is significant that 26 of the 2900 participants in two running events during the summer of 1978 were hospitalized because of heat-related injuries. Further, a large number of minor heat injuries occurred that required first aid at the race site; we did not study them. Heat stroke, a life-threatening situation, has become the most serious medical problem in mass participation runs.²⁴

Heat stroke is characterized by a rectal temperature in excess of 41°C,^{5,7} serious alterations in mental status, including disorientation or coma,^{6,7} and elevated serum enzyme levels.⁷ Unlike the prospective study of Costrini and colleagues⁶ and the detailed studies of Richards and collaborators,³ who documented the clinical state, including the rectal temperature, at the race site, our study had a serious weakness in that the rectal temperature at the race site was not recorded. Further, the hospital records did not reflect the mental status at the time of collapse, as some victims of the Toronto run were observed to be unconscious at the race site but were reported to be alert when admitted to hospital. This variation in diagnosis was probably due to the vigorous treatment administered before admission to hospital. We therefore decided to use the term collapse, which we define as an inability to run, with or without serious alterations in mental status.

We attempted to identify the factors that predisposed to heat injury by means of a retrospective survey. This method has many drawbacks. A more reliable approach may be to use the case-control technique, in which a survey is also done of an appropriately stratified and matched random sample of the competitors who did not collapse; however, a large sample is usually required to identify significant predisposing factors. Such an approach is presently being

applied to the Peachtree Road Race in Atlanta, Georgia (T. England: personal communication, 1979). Nevertheless, the combination of inexperience with competitions and the extremes of the Canadian climate probably contributed to the large number of collapses due to heat injury in the races we studied.

All the persons who collapsed in these two runs and were admitted to hospital were novices to 10-km races. Experienced runners are much more conscious of the intensity of their effort and are capable of making fine adjustments to ensure racing success.⁸ This may be reflected by two observations from our study. First, none of the experienced, elite racers were admitted to hospital, although at least one of the Waterloo runners had significant discomfort. Second, the relatively low effort ratings given by most of the patients may indicate that in the excitement of competition the novice runner cannot accurately judge an effort that will result in collapse. However, other participants in these two races with experience and training equal to those of the hospitalized patients did not collapse. The possibility exists that the people who collapsed were part of the population suggested by Wyndham⁹ to be more susceptible to heat injury.

The Canadian climate provides extremes in temperature that, especially in early summer, may place an unexpected burden on an unacclimatized thermoregulatory system. The Waterloo run was held on a moderately hot day; more important, however, it was the hottest day of the summer so far. The solar radiation of mid-day, when the race started, added to the thermal load. Gisolfi, Wilson and Claxton¹⁰ have clearly shown that at least 1 week of exercise in the heat is required for substantial heat acclimatization. Heat acclimatization may have resulted in the lower incidence of collapse in the hotter Toronto run, which was held 2 months further into the summer.

It has been proposed by a number of authors that fluid consumption before or during an endurance activity will assist in the maintenance of thermal balance.¹¹⁻¹⁵ In these two races, however, fluid consumption before and, in most cases, during the event did not prevent collapse due to heat injury. On hot, humid days with intense solar radiation the thermoregulatory mechanisms, even with maximum sweating, may not be able to generate the necessary heat loss to counter heat production and absorption (R.L. Hughson and J.R. Sutton: unpublished data).

Because of the wide variation in climatic conditions under which collapse due to heat injury has occurred, it is not possible to set a lower limit for temperature that will eliminate all such injuries. Unusually hot days in the spring and early summer present a greater threat to competitor safety than equally hot days in mid-summer. Clearly, race organizers should consider guidelines such as those given elsewhere in this issue of the Journal (on page 1119) and be prepared to cancel an event if the competitors' lives are endangered.

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Exertional heat stroke: the runner's nemesis

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Heat stroke in distance runners is increasing in frequency. A case is reported of a 41-year-old man who collapsed during a 10-km "fun run" held when the temperature was 31.6°C and the humidity 80%. Acute renal failure (serum creatinine level 1530 $\mu\text{mol/l}$ [17.3 mg/dl]), rhabdomyolysis, disseminated intravascular coagulation and hepatic damage complicated the clinical picture. Repeated peritoneal dialysis and one cycle of hemodialysis because of a very high serum level of uric acid (1.23 mmol/l [20.7 mg/dl]) were required. Although the illness was prolonged, recovery was almost complete, and 4 months after the man's collapse the serum creatinine level had fallen to 133 $\mu\text{mol/l}$ (1.5 mg/dl).

Chez les coureurs de fond la fréquence des coups de chaleur vont en augmentant. On signale le cas d'un homme de 41 ans qui s'effondra pendant une course "d'agrément" de 10 km tenue par une chaleur de 31.6°C et une humidité de 80%. Une insuffisance rénale aiguë (avec un taux de créatinine sérique de 1530 $\mu\text{mol/l}$ [17.3 mg/dl]), une lyse des fibres musculaires avec myoglobulinurie, une coagulation intravasculaire disséminée et des dommages hépatiques vinrent compliquer le tableau clinique. Des dialyses péritonéales répétées et une session d'hémodialyse rendue nécessaire par une uricémie très élevée (1.23 mmol/l [20.7 mg/dl]) furent requis. Bien que la maladie fût longue

la guérison fut presque complète, et 4 mois après le collapsus de cet homme le taux de créatinine sérique s'était abaissée à 133 $\mu\text{mol/l}$ (1.5 mg/dl).

Prolonged physical activity in the presence of high environmental temperature and humidity enhances the risk of heat stroke. This condition has been reported in military recruits, distance runners, cyclists and North American football players. With an estimated 25 million Americans and 1 million Canadians participating in organized road races annually, it is not surprising that exertional heat stroke is occurring with increasing frequency among distance runners.¹⁻⁴

Casualties are more common in novices who exceed their training efforts when racing and in well trained competitors who strive for improved performance by suddenly increasing their pace midway through a long-distance event. But the problem does not end here; under adverse environmental conditions even the most accomplished athlete is at risk.

The purpose of this report is to describe a case of heat stroke in an experienced runner who participated in a race conducted under extreme environmental conditions.

Case report

A 41-year-old man collapsed after 9 km of a 10-km "fun run" in Hamilton June 10, 1979. He had been physically active since adolescence and had been jog-

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